E-ISSN: 2717-2937 | P-ISSN: 2783-1337

International Journal of Research in Industrial Engineering

www.riejournal.com

Int. J. Res. Ind. Eng. Vol. 12, No. 1 (2023) 88–105.

Paper Type: Research Paper

Identifying and Prioritizing Technology Capability Drivers in the Supply Chain Using the Fuzzy Hierarchical Analysis Process (Case Study: Iran Khodro and Saipa Automotive Company)

Ali Ehsani[1], Hassan Mehrmanesh[1,*], Mahmoud Mohammadi[1]

[1] Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran; ali.ehsani.mng@iauctb.ac.ir; has.mehrmanesh@iauctb.ac.ir; mah.mohammadi@iauctb.ac.ir.

Citation:

Ehsani, A., Mehrmanesh, H., & Mohammadi, M. (2023). Identifying and prioritizing technology capability drivers in the supply chain using the fuzzy hierarchical analysis process (case study: Iran Khodro and Saipa automotive company). *International journal of research in industrial engineering, 12*(1), 88-105.

Received: 01/03/2022 Reviewed: 02/04/2022 Revised: 12/05/2022 Accepted: 22/06/2022

Abstract

This study aims to identify and prioritize the effect of technology capability drivers on the supply chain performance of automotive companies. Technology capability indicators are ranked and prioritized using the fuzzy hierarchical analysis technique. The research method is applied in terms of purpose, is described as the data collection method, and is considered quantitative research. After reviewing the theoretical literature of the research, the drivers of technology capability on the organization's performance were identified for prioritization; they were weighed by a number of experts in the field of automotive companies using questionnaires and fuzzy hierarchical analysis. Indicators and sub-indices of variable technology capability were ranked and prioritized. Based on the results of this research model, it was found that of the eight indicators examined, "strategic technology capability", "product technology capability", and "supplier technology" was the most important, and of the 38 technology capability sub-indicators examined, "technology development" is the most important.

Keywords: Technology capability, Organization performance, Supply chain, Iranian automotive industry, Fuzzy hierarchical analysis.

1 | Introduction

Due to the rapid globalization and the need for companies to compete fiercely in the global arena, technology capability is considered a competitive advantage factor to be present in the worldwide market. Therefore, technology capability is a prerequisite for today's organizations' economic growth, is regarded as a golden key in the business environment, and is an essential weapon in competition between companies [12]. Technology development requires continuous activities rooted in organizational policies and processes and is referred to as technical capability. With the help of technology capability, the necessary infrastructure for investment can be created. Technology also increases production efficiency and consequently increases productivity [37].

Corresponding Author: has.mehrmanesh@iauctb.ac.ir

https://doi.org/10.22105/riej.2022.332012.1301

The capability of technology contributes significantly to the promotion and facilitation of trade. Technology capability is an essential factor in increasing competitiveness at the enterprise level. Because it helps businesses gain a competitive advantage by differentiating products, creating new business opportunities, and reducing costs [34]. Technological innovation capabilities are the decisive and fundamental supporting factors of competitive advantage, and the survival and development of modern organizations depend on knowledge, applications, and technological innovation. However, for many organizations, the relationship between investment capability and technological innovation capabilities and how it affects technological innovation capabilities and the firm's competitive performance is still unclear [12].

Technology capability is the efficient application of technological knowledge to create, apply, disseminate, accept and change existing technologies [9]. This concept refers to organized research and development in developed countries and focuses on concepts such as the commercial exploitation of technology. Implementing technology in businesses such as manufacturing companies must be integrated with dynamic areas such as supply chain management. Because this makes it possible to control the management of material resources better, avoid production delays and thus increase compliance with customer demands [33].

An efficient and capable supply chain is also an essential and decisive competitive advantage in a competitive supply chain [19]. The supply chain is a complex network of facilities that design, supply, manufacture, and deliver commodities to customers in the appropriate amounts, locations, and times. The supply chain is highly complex and constantly evolving due to globalization, diversity, flexibility, sustainability, and uncertainty [19].

Companies need to combine technology-related resources with their unique capabilities and lead to superior performance [15]. It is necessary to examine the performance of organizations given the complex and competitive conditions that have arisen over the past few years. Hence, organizations strive to improve their performance to survive and achieve a better position than other organizations. Organizational performance is a multi-dimensional concept of organizational effectiveness and operational efficiency [36]. Organizational performance includes selecting, implementing, and monitoring performance metrics; therefore, organizational efficiency and effectiveness can be based on productivity, effectiveness, service quality, customer satisfaction, and efficiency [18].

Recent research in resource-based perspectives assumes that organizations' performance level varies according to technological capabilities [13]. Organizations in the contemporary world are changing rapidly, and in the current system, improving the performance of the organization is one of the main goals of any organization. Therefore, identifying the variables affecting the performance of organizations and prioritizing and ranking these factors is necessary to improve, upgrade and develop the performance of an organization [16].

Among the many necessities of life, the automotive industry is of great importance and sensitivity in terms of the extent and use of automobiles by different social groups. The automotive industry is one of the most critical industries in the world economy. Due to its wide connection with other industries, it is referred to as the locomotive of industries. For this reason, reviewing its developments and trying to improve the capability of technology and market expansion is one of the essential measures in the domestic and international arena.

Examining the research background and literature, it was discovered that earlier investigations in fuzzy environments and employing hierarchical analysis did not study and analyze the capabilities of technology. Similarly, the capacity of supply chain technology in the automotive industry has not been done in previous research, all of which will be examined in this study.

This research attempts to prioritize and rank the indicators and sub-indicators of technological capability in the automotive industry's supply chain. Consequently, the following research question is posed: what is the relative importance and priority of each of the indicators and sub-indicators of supply chain technological competence that influences the organization's performance in the automotive industry?

According to the structure of the article, after reviewing the theoretical literature of the research, the drivers of technical capability in the supply chain were identified. Then, using fuzzy hierarchical analysis and surveys, several experts in the automotive industry and supply chain weighted these indicators based on pairwise comparisons. The research findings were discussed and then concluded.

2 | Literature Review

2.1 | Theoretical Foundations and Research Background

2.1.1 | Theoretical foundations of research

Some researchers and scholars have provided definitions of technology capability, reflecting their attitude towards their expertise and research areas. The capability of technology is the knowledge used in an effective and productive endeavor. The capability of technology is the tool or method, product, process, physical equipment, or methods by which human capabilities emphasize the machine aspect of technology [27].

One of the driving forces for long-term economic development is technological capabilities. The impacts of technology capabilities have been investigated in national and international studies. Technology capability is related to skill, the knowledge required by the company, acceptance, transfer, and development of the company's technologies. It plays a vital part in achieving productivity in the production process and the degree of innovation of the company [12].

Technology capability can be considered a continuous process of absorbing or producing technology that allows companies to offer distinctive products and services. There are various definitions of technology capability in the research literature, some of which refer to structural factors and others to practical and strategic elements of companies. Some researchers have referred to specific and internal aspects of the company [26]. Some have also referred to the external contexts of companies. Technology capability refers to the ability to absorb, use, accept, apply, transfer and disseminate technology, which includes a set of resources and skills (operational, organizational, and relational) and learning mechanisms. There are two basic approaches to measuring and defining technology capability. The first approach is the process aspect of technological capability, including the set of organizational methods and processes. The second approach is output-oriented, including trade secrets, technological knowledge, and technical knowledge produced by research and development and technological properties such as patents [9].

The three main dimensions of investment capability, production capability, and communication capability are introduced to measure the capability of technology, each of which includes its processes [35].

Technology capability is a factor that differentiates a company from other companies and keeps companies alive [16]. In today's competitive world, maintaining a competitive advantage has become difficult due to the development of markets, competitors' influence, and the presence of different customers. Competitive advantage due to the capability of technology helps to create and maintain companies over time. It can be considered the core of the success or failure of companies compared to competitors [4].

Ehsani et al.| Int. J. Res. Ind. Eng. 12(1) (2023) 88-105

The efficient evaluation of technological innovation capabilities of enterprises is an essential factor in enhancing competitiveness. In a study, to evaluate and rank the criteria for technological innovation, a framework is proposed and uses a novel hybrid Multiple Criteria Decision Making (MCDM) model to address the dependence relationships of criteria with the aid of the Decision-Making Trial and Evaluation Laboratory (DEMATEL), Analytical Network Process (ANP) and VIKOR. The study reports that the interaction between criteria is essential and influences technological innovation capabilities; furthermore, this ranking development of technological innovation capabilities assessment is also one of the crucial management tools for the management of other related high-tech enterprises [20].

National and regional growth and development models in developing countries, whose development attributes are far different from those of the developed countries, must be in such a way to allow the corresponding country or region to develop at the minimum cost within the shortest possible period. One of the successful approaches toward national and regional development models is relying on a development model based on extending and developing science and technology corridors. This study uses multiple attribute decision-making processes to rank practicable technologies within Isfahan's science and technology corridor. This research's outstanding criteria are applying three decision-making methods for upgrading reliability. For this purpose, 13 attributes were utilized (categorized into six groups). AHP, TOPSIS, and SAW techniques were employed to rank technologies so that the following order of preference was suggested for the practicable technologies within the science and technology corridor of Isfahan: 1) information and communication technology, 2) material technologies, 3) biotechnology, 4) energy technology, 5) Nano-technology, 6) environmental technology, 7) laser and optic technology and 8) nuclear technology [25].

To compete in the global environment, a manufacturing company has to keep developing new technologies. The right technology selection is critical in a successful technology transfer process. However, technology selection is a complex multi-dimensional problem including qualitative and quantitative factors, such as human resources and operational and financial dimensions, which may be in conflict and uncertain. In addition, interdependent relationships exist among various dimensions as well as criteria of technology selection. The identified problems could be solved by combining MCDM methods of different nature and fuzzy set theory. The research objective was to develop a complex approach to evaluate technologies and rank their appropriateness for a company. A hybrid model is proposed based on the Fuzzy Analytic Network Process (FANP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) [3]. The organization's performance management is a critical component that directly affects the organization's total performance and the competitive environment.

This paper aims to prioritize alternatives related to manager(s) performance in an organization using multi-criteria decision-making, i.e., PROMETHEE, ELECTRE, and TOPSIS, and provide a model for it. The mean Maximum-Minimum Square Ranks method is proposed to combine the results obtained from applying multi-criteria decision-making methods. Also, roadmaps are presented for alternatives with higher priority for the organization. The proposed model allowsfor solving issues related to organizational performance by analyzing various options and criteria for organization manager(s) [1].

Achieving a competitive advantage leads to the competitive dynamics of companies. In a way, the most basic concept of competitive advantage refers to the company's use of resources to achieve superior performance; the three main elements can lead to differentiation and difference compared to other competitors. These factors include sources of competitive advantage, competitive advantage, and company performance [8].

Recently, competitiveness and productivity awareness have increased rapidly among different industries. Hence, the performance evaluation of the productivity criteria is needed to improve productivity and strengthen the organization's management. In this study, a two-phased research method has been projected to determine some governing factors affecting the industry’s output. In the first phase, six criteria associated with productivity have been identified based on literature, inputs from experts, and opinions

from the officials and managers of six garment industries in Bangladesh. In the second phase, among different MCDM tools, the Fuzzy Analytic Hierarchy Process (FAHP) has been used for evaluating criteria weights and ranking the criteria. The line-balancing criterion is the most critical factor in improving the RMG's productivity [14].

Efficient Inter-Organizational Information Systems (IOIS) have become the backbone of modern supply chains. IOIS can plan, coordinate, collaborate and integrate supply chains to attaina competitive advantage. The speed of innovative technology evolvement, lack of clarity, and delay in taking appropriate managerial and strategic decisions for adopting IOIS demand further research in this area. The robust advancement in digital technologies stresses a proper decision model for the IOIS adoption process. This research provides a novel model for selecting the best IOIS alternative by considering the contents, scope, and critical decision-making factors affecting supply chain integration. Twelve decision-making factors affecting IOIS selection were identified and categorized under four significant dimensions: technological, operational, application, and innovative for effective decision-making [10].

In the context of innovation-driven strategy, the role of suppliers has been attracting much attention. Scientifically selecting an innovative supplier is highly valued by decision-makers. A study focuses on proposing a novel decision framework in the context of collaborative innovation, which helps manufacturers select an innovative supplier who can work hand in hand with them to enhance their innovation performance. First, a novel Capability-Willingness-Risk (C-W-R) evaluation indicator system is established, considering supply risk from a multi-proximity perspective tightly tied to collaborative innovation performance, only thought from geographical proximity in previous supplier selection research. Then a hybrid fuzzy-symmetrical MCDM model is proposed that integrates fuzzy linguistic sets, Best–Worst Method (BWM), Prospect Theory (PT), and VIKOR. This approach obtains a final ranking for innovative supplier selection [22].

A supply chain is an integrated system of interrelated equipment and activities thatdeals with the production process, transfer, and distribution among customers. The fundamental problems in the supply chainare generally divided into three categories: 1) supply chain design, 2) supply chain planning and 3) Supply chain control. In the chain design phase, strategic decisions such as the facilities' location and the appropriate technology selection are taken [31].

Supplier selection is one of the most critical activities of purchasing management in a supply chain. Because selecting suitable suppliers helps reduce purchasing costs, improve the quality of final products and services, etc. In an actual situation, for a supplier selection problem, most input information is not known precisely since decision-making deals with human judgment and comprehension, and its nature includes ambiguity. In fact, on the one hand, deterministic models cannot easily take this vagueness into account. In these cases, the theory of fuzzy sets is one of the best tools to handle uncertainty.

On the other hand, Kavilal et al. [19] proposed a new approach to finding the fuzzy optimal solution to a fully fuzzy linear programming problem. So, this approach in this paper presents a new mixed integer multi-objective linear programming model for the supplier selection problem. Due to the uncertainty of the data, in continuation, we offer a new method to solve multi-objective fully fuzzy mixed integer linear programming and implement the methodologyfor supplier selection problem. Computational results present applying the technique and the proposal-solving method [19].

Supply chain design has always been one of the most critical operational decisions of every organization since the availability of the proper supply system, in addition to reducing system costs, accelerates the delivery and receipt of goods, thereby improving the entire system [5].

The supply chain has been widely discussed in the management literature. In supply chain management, the decision to select a supplier is one of the critical issues made by purchasing and operations managers

to maintain the competitive position of organizations. Globalization and outsourcing have added to this competitive pressure to the point where supplier selection has become a vital issue [19].

Nowadays, increasing environmental and social awareness has led numerous industries to adopt Sustainable Supply Chain Management (SSCM). Sustainable Supplier Selection (SSS) is a significant and primary step in achieving an SSCM. SSS is an MCDM problem and is very intricate in its nature. This study aims to evaluate and rank sustainable suppliers using Data Envelopment Analysis (DEA), a popular model for measuring the productive efficiency of decision-making units effectively and can also handle MCDM problems. An evolutionary algorithm, Differential Evolution (DE), is used to solve the DEA model, avoiding some inherent limitations of DEA. This integrated DEA-DE model provides more accurate efficiencies. Employing this easy and fast model to assess sustainable suppliers will help industries and suppliers move towards achieving and maintaining sustainability and thus will increase the overall performance of SSCM [28].

2.1.2 | Empirical background of the research

In a study, researchers examined the impact of technology capability flexibility infrastructures on the competitive advantage of small, medium, and large companies. According to the findings of this study, having a flexible technology infrastructure positively impacts competitive advantage [21].

The investigation of competitive strategy, technical capabilities, and organizational performance in the manufacturing industry revealed that technological capabilities influence organizational performance and can contribute to competitive advantage [27].

According to a study, technology capabilities refer to the company's internal competencies or relative strength compared to other companies. Companies' technological capabilities are strongly tied to their technological innovation. Technology capabilities depend on how the company has performed in the past and are likely to lead to a successful path. Technology capabilities can increase the value of the company by using external knowledge. High-tech companies have a high motivation to acquire knowledge, unite and mobilize resources, and these companies have an increased ability to benefit from external resources [34].

Researchers examined the impact of technology on supply chain performance. The findings revealed that technological capabilities enhance logistics efficiency, operational efficiency, customer communication, proper communication with suppliers, and competitive advantage. The final results indicate that creating the correct supply chain is critical to getting a competitive edge [35].

According to a study by De Mori et al. [9], technology's capabilityis vital in achieving productivity in the production process. The degree of innovation of the company, which is associated with skills, the amount of knowledge required to accept the company, acceptance, transfer, and the development of company technologies, is relevant and serves as a channel to solve companies' problems. Technology capability can be used as a quantitative and qualitative criterion for solving problems. Technological capability can be a tool for analyzing performance and making decisions and a source of technology dynamism in an organization [9].

Collaborating with six institutes in the Netherlands, Norway, the United Kingdom, and Italy presented an integrated model for assessing technology capability. Different functional layers were examined in this model, which was implemented in health care. Finally, by offering an integrated evaluation model of Gerhados technology, a comprehensive approach to the systematic evaluation of technology has been suggested [7].

In a study by Radfar and Khamseh [30], they introduced the model of technology needs. This model identifies and determines the capabilities needed to implement technology priorities in developing

countries. Through this model, the capabilities of firms are measured from 3 dimensions based on a questionnaire that, after completing it by experts, their scores are added together, and the total score is compared with the table related to the form of determining the results of technology needs assessment and finally between four levels. In terms of capability (firm type I: passive, firm type II: reactive, firm type III: strategic, firm type IV: creative), the level of capability of the firm is determined [30].

In a study by Mikalef and Pateli [23], they examined the dynamic capabilities of technology and its impact on competitive performance. The results showed that dynamic technology capabilities affect operational and market capital agility, and technology capabilities indirectly affect competitive performance [23].

Dynamic capabilities, creativity and innovation capabilities and their impact on competitive advantage and company performance

The role of adjusting entrepreneurial orientation is the focus of a study. This study defines dynamic ability as the ability for systematic problem-solving that varies with the desire to detect opportunities and threats, make timely decisions, and effectively implement strategic decisions, ensuring the appropriate direction. In addition, the two-way viewpoint investigates the indirect influence of exploitation and exploration capabilities via creativity and innovation capabilities, providing proof of the impact on a company's competitive advantage and performance [12].

Research on technology capability, environmental innovation performance, and collaborative research and development strategies in the new energy vehicle industry: evidence from Chinese companies. The study is based on a unique collection of panel data from 127 companies in China's automotive industry from 2009 to 2018. Empirical findings show that firm-level technology capability is positively correlated with the performance of environmental innovations, and government ownership is enhanced. Surprisingly, this positive relationship weakens the increase in government subsidies. The results also show that companies with higher technological capabilities prefer collaborative R&D. In comparison, companies with lower technical capabilities tend to have in-house R&D. These findings increase the understanding of the cost-effectiveness of R&D investment in the energy technology industry and shed light on the interaction of internal and external resources. This study presents management concepts to promote industry prosperity [37].

In a study by Qin et al. [29], they researched the impact of technology capability and infrastructure capability on new product development performance, market knowledge's role, and innovation's formalization process. This study shows how the capacity of technology infrastructure affects the implementation of new product development by considering market knowledge as a mediator and innovation processes as a moderator. The study provides empirical evidence that technology infrastructure capability is not only directly and positively related to new product development performance but also indirectly related to the use of market knowledge. Further results show that the formal innovation process weakens this relationship. Overall, this study expands the understanding of how technology infrastructure capability affects new product development performance and can be helpful for managers looking for superior recent product development performance [29].

In the current intense competitive environment, companies continuously need to increase their performance and adapt their activities to the developing and changing environment to survive. The concepts of quality, technology, and innovation are among the most prominent issues in this competitive environment. At this point, recently emphasized information technologies integrated into the business, innovation activities, and logistics services that develop along with these activities are essential issues. Accordingly, this study aims to reveal the role of information technology use in supply chain innovation and logistics service quality. According to the results, it has been determined that information technologies mediate between innovation capability in the supply chain and logistics service quality [2].

Ehsani et al.| Int. J. Res. Ind. Eng. 12(1) (2023) 88-105

3 | Research Methodology

The present study is applied in terms of purpose and is considered quantitative research. Also, in terms of the data collection method, it is "descriptive (non-experimental)", which is regarded as a survey-single-section type due to the use of the fuzzy hierarchical analysis method [32].

The statistical population in this study is domestic car companies, Iran Khodro Industrial Group, and Saipa Automotive Group and their supply chain. A questionnaire was designed to compare the main dimensions of "technology capability" and compare sub-indicators of each dimension, which was agreed upon by ten experts in the field of automotive and supply chain at management levels with at least five years of experience and master's degree and above, it was answered. Statistical samples of this study were selected as snowballs (chain reference). The fuzzy hierarchical analysis process was used to weigh the identified indicators.

According to *Table 1*, the main elements of the model are identified along with the variables and technology capability items in the supply chain. After the initial design of the model, through reviewing the research literature, the content validity of technology capability was assessed by surveying professors and experts in the field of the automotive supply chain; in this way, a questionnaire consisting of identified components was provided to the experts, and they were asked to rate the relevant details based on a nine-point Likert scale. Also, at the end of the questionnaire, space was considered to comment on the components not mentioned in the questionnaire. Finally, factors with a score of more than 5 or 7 were selected. The main items of the questionnaire for the second-order hidden variable of the model are presented in *Table 1*.

Table 1. The analytical research model for supply chain technology capability.

Variable	Code	Item	References
Product technology capability (A)	A1	Technology creation	[13], [15]
	A2	Technology transfer	[13], [15]
	A3	Implementation and application of technology	[9], [34]
	A4	Cost savings by technology	[12], [26]
	A5	Update and use technology	[12], [27]
Process technology capability (B)	B1	Process efficiency by technology	[9], [34]
	B2	Improving service delivery by technology	[27], [30]
	B3	Reduce process time	[13], [37]
	B4	Reduce operating costs	[34], [37]
	B5	Compliance of production with engineering specifications	[12], [37]
Supplier technology and supply chain (C)	C1	The extent of technology knowledge absorption	[12], [34]
	C2	Acceptance of new technologies	[15], [35]
	C3	Technology transfer and development	[30], [34]
	C4	Operational effectiveness	[19], [33]
	C5	Improve logistics efficiency	[19], [33]
The capability of core and backup activities (D)	D1	Infrastructure development	[12], [37]
	D2	Upgrading the human resource management system	[16], [36]
	D3	Supporting technology development	[12], [37]
	D4	Supply and supply of technology needs	[9], [30]
	D5	Financing for technology development	[34], [37]
Tools and skills (E)	E1	Proper organization and management in line with technology	[12], [30]
	E2	Utilization of new production machines and tools	[9], [12]
	E3	Improving human resource skills and experiences	[16], [36]
	E4	Examine the limitations in the use of technology	[37]
	E5	Increase the amount of information and technical knowledge	[21], [29]
Tools and skills (E)	F1	Develop a vision and strategy for technology innovation	[12], [37]
	F2	Identify internal strengths and weaknesses and external technological opportunities and threats	[12], [37]
	F3	Technology-based performance support	[15], [34]
	F4	Technology development	[12], [37]

Table 1. Continued.

Variable	Code	Item	References
Investment capability (G)	G1	Optimal allocation of capital	[18], [37]
	G2	Purchase of intangible technology such as licenses and patents	[36], [37]
	G3	Adequate purchase of tangible technology such as equipment and machinery	[33], [37]
	G4	Allocate a share of revenue to research and development	[15], [37]
Organizational capabilities (H)	H1	Reproduction and expansion of technology	[8]
	H2	Maintain existing technologies	[26]
	H3	Technology monitoring	[9]
	H4	Adaptation and improvement of technology	[12], [15]

3.1 | Fuzzy Hierarchical Analysis Process Method

The fuzzy hierarchical analysis is used to measure the technology capability model. The traditional hierarchical analysis process does not fully reflect the human thinking style. In other words, fuzzy sets are more compatible with linguistic and sometimes ambiguous human explanations, so it is better to use fuzzy sets (using fuzzy numbers) to make long-term predictions and decisions in the real world. The fuzzy hierarchical process [6] method is used in this research.

In the fuzzy hierarchical analysis technique, a pairwise comparison of each model level's elements must be performed after drawing the hierarchical decision tree. In the calculation stage, the coefficients of each pairwise comparison matrix are calculated using the definitions and concepts of fuzzy hierarchical analysis. For each row of the pairwise comparison matrix, the value of SK, which is itself a triangular fuzzy number, is obtained from *Eq. (1)*. *Eqs. (2)* to *(4)* calculate each part of this relationship.

$$S_k = \sum_{j=1}^{n} M_{ki}^{j} \otimes \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij}\right]^{-1}. \quad (1)$$

$$\sum_{j=1}^{m} M_{ij} = \left(\sum_{i=1}^{m} l_j, \sum_{i=1}^{m} m_j \sum_{i=1}^{m} u_j\right), \quad i = 1,2,\dots,m. \quad (2)$$

$$\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} = \sum_{i}^{n} l_i, \sum_{i}^{n} m_i \sum_{i}^{n} u_i). \quad (3)$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ki}^{j}\right]^{-1} = \left[\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right]. \quad (4)$$

After calculating all the Sk, in this step, we have to calculate the magnitude of each surface element on the other elements of that level separately, according to the following equations:

$$\begin{cases} V\ M_1 \geq M_2) = 1, & \text{if } m_1 \geq m_2, \\ V\ M_1 \geq M_2) = 0, & \text{if } l_2 \geq u_1, \\ V\ M_1 \geq M_2) = \text{hgt } M_1 \cap M_2), & \text{otherwise.} \end{cases} \quad (5)$$

$$\text{hgt } M_1 \cap M_2) = \frac{l_2 - u_1}{m_1 - u_1) - m_2 - l_2)}. \quad (6)$$

The magnitude of a triangular fuzzy number is obtained from k of another triangular fuzzy number from *Eq. (7)*:

$$V\ M_1 \geq M_2, \dots, M_k) = V\ M_1 \geq M_2) \text{ and } \dots \text{ and } V\ M_1 \geq M_k). \quad (7)$$

To calculate the weight of the indices in the matrix of pairwise comparisons, we do the following:

$$W'\ x_i) = \{V(S_i \geq S_k)\}, \quad k = 1,2,\dots,n, k \neq i. \quad (8)$$

Therefore, the weight vector of the indices will be in the form of *Relation (9)* or the same vector of abnormal coefficients of fuzzy hierarchical analysis.

$$w' = [w'\,x_1), w'\,x_2), \dots, w'\,x_n)]^t. \tag{9}$$

3.2 | Calculate the Compatibility of Fuzzy Pairwise Comparison Matrices

Deng [11] proposed a method for calculating the degree of compatibility of paired fuzzy comparison matrices based on strong transmittance conditions. In this method, to investigate the compatibility conditions, it is necessary to form two separate matrices Ag and Am from each pair comparison matrix $\tilde{A}(n \times n)$. The matrix Am is obtained from the median values of the preferences of each expert (median values of fuzzy triangular numbers). (Am = [aijm]) the second matrix (Ag) is created from the geometric mean of the upper limit and the lower limit of fuzzy triangular numbers (*Eq. (10)*).

$$A^g = \sqrt{a_{ijI} \cdot a_{ijU}}. \tag{10}$$

The weight vector of each of these two matrices must be calculated to find the degree of compatibility. Because these matrices contain non-fuzzy data, the Saaty method can be used to calculate the weight vector. Hence, the vectors Wg and Wm are obtained from *Eqs. (11)* and *(12)*.

$$w^m = [w_i^m] \quad \text{where} \quad w_i^m = \frac{1}{n}\sum_{j=1}^{n} \frac{a_{ijm}}{\sum_{i=1}^{n} a_{ijm}}. \tag{11}$$

$$w^g = \left[w_i^g\right] \quad \text{where} \quad w_i^g = \frac{1}{n}\sum_{j=1}^{n} \frac{\sqrt{a_{ijL} \cdot a_{ijU}}}{\sum_{i=1}^{n} \sqrt{a_{ijL} \cdot a_{ijU}}}. \tag{12}$$

n is the dimension of the matrix. Each matrix's largest special amount (λmax) is calculated from *Eqs. (13)* and *(14)*.

$$\lambda_{max}^m = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ijm}\left(w_j^m / w_i^m\right). \tag{13}$$

$$\lambda_{max}^g = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \sqrt{a_{ijL} \cdot a_{ijU}}\left(w_j^g / w_i^g\right). \tag{14}$$

Based on the Saaty method, the Consistency Index (CI) for measuring the reliability of the first questionnaire, which shows the deviation from full compliance, is obtained in the following order:

$$CI^m = \frac{\lambda_{max}^m - n)}{n-1)}. \tag{15}$$

$$CI^g = \frac{(\lambda_{max}^g - n)}{n-1)}. \tag{16}$$

$$CR = \frac{CI}{RI}. \tag{17}$$

Table 2. Random indices of Deng.

Matrix Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rm	0	0	0.489	0.793	1.072	1.199	1.287	1.341	1.379	1.409	1.418	1.446	1.455	1.491	1.499
Rg	0	0	0.179	0.262	0.359	0.381	0.4090	0.416	0.4348	0.445	0.453	0.477	0.469	0.480	0.488

If both (CRm and CRg) compatibility values of each pairwise comparison matrix are greater than 0.1, the expert should be asked to reconsider their preferences. Suppose only CRm or CRg is greater than 0.1, and another is acceptable in the set. In that case, it is better to persuade the decision maker to re-evaluate the intermediate values and keep the limit values unchanged, but given that in this study of standard Chang triangular fuzzy numbers, which has a special relationship between the lower limit, the median value and the upper limit of each number, is used. In case of incompatibility of either of these two matrices, the preferences of the respective matrix should be reconsidered in general.

Ehsani et al.| Int. J. Res. Ind. Eng. 12(1) (2023) 88-105

4 | Research Findings

After studying the research literature and identifying the drivers of technical capability in the automotive industry supply chain, the recognized model serves as the foundation for fuzzy hierarchical analysis, and the weighting of the model's indicators and sub-indices are examined.

The pairwise comparison questionnaire of the main dimensions of "technology capability" and the comparisons of the sub-indicators of each dimension was provided to several experts in the automotive industry and supply chain. It was decided to answer the questionnaire in an agreed manner. Technology competency indicators were weighed through a hierarchical process and questionnaire data. The fuzzy hierarchical process method was obtained by formulating the final pairwise comparison matrices in matrix Excel software. The final weighting of the indices was calculated by multiplying the weight obtained by each index in its subgroup in the respective next weight. The incompatibility of each pair of comparison tables was individually calculated (the incompatibility of each matrix should be less than 0.1) to test the questionnaire's reliability (to determine the compatibility or incompatibility of opinions).

The final weight of each sub-index in the whole technology capability model is obtained by using the importance of the main index multiplied by the weight of the sub-index in their group. The final weight obtained for each sub-index and their priority and rank among the indicators of the technology capability model is described in *Table 3*.

Table 3. Weights and ranks of indicators and sub-indicators of the technology capability model.

The Main Indicator	Index Rank	Sub-Index Rank	Subscript	Weight of the Main Indicators	Sub Weight Index
Product technology capability (A)	2	4	A1	0.228	0.098
		5	A2		0.065
		1	A3		0.421
		3	A4		0.199
		2	A5		0.215
Process technology capability (B)	7	1	B1	0.035	0.379
		3	B2		0.175
		4	B3		0.096
		5	B4		0.067
		2	B5		0.281
Supplier technology and supply chain (C)	3	3	C1	0.153	0.152
		2	C2		0.291
		1	C3		0.394
		4	C4		0.095
		5	C5		0.067
The capability of core and backup activities (D)	8	1	D1	0.024	0.405
		2	D2		0.253
		3	D3		0.178
		4	D4		0.096
		5	D5		0.067
Tools and skills (E)	5	2	E1	0.108	0.269
		1	E2		0.408
		4	E3		0.091
		3	E4		0.162
		5	E5		0.068
The strategic capability of technology (F)	1	2	F1	0.263	0.257
		3	F2		0.150
		4	F3		0.093
		1	F4		0.498
Investment capability (G)	6	1	G1	0.045	0.429
		3	G2		0.143
		4	G3		0.092
		2	G4		0.334
Organizational capabilities (H)	4	2	H1	0.144	0.257
		3	H2		0.155
		1	H3		0.415
		4	H4		0.113
		5	H5		0.058

According to the results of the fuzzy hierarchical analysis process and the data in *Table 3*, the dimension of "strategic capability of technology," with a weight of 0.263, had the highest score. The final weights of the sub-index are 0.498 for "technology development," 0.257 for "development of vision and strategy for technology innovation," respectively, "identification of internal strengths and weaknesses and external opportunities and threats of technology." Equivalent to 0.150, "technology-based performance support" equals 0.093.

Next, "product technology capability" gained the weight of 0.228 in second place. The final weight of the sub-indices for "implementation and application of technology" is equal to 0.421, "update and use of technology" are equal to 0.215, "cost saving" is equal to 0.199, "technology creation" was equal to 0.098, and "technology transfer" was equal to 0.065.

According to *Table 3*, the "supplier technology and supply chain" dimension weighs 0.153. The final weights of the sub-indices are "technology transfer and development" equal to 0.394, "acceptance of new technologies" equal to 0.291, "technology knowledge absorption rate" equal to 0.152, and "operational effectiveness," respectively. Equal to 0.095, "improvement of logistic efficiency" is equal to 0.067.

Similarly, the weight of the following "organizational capabilities" was calculated to be 0.144 percent. The final weights of the sub-indices are equal to 0.415 for "technology monitoring," 0.257 for "technology reproduction and expansion," 0.155 for "maintenance of existing technology," and "adaptation and improvement of technology," respectively. With 0.113, the "ability to update technology" was equal to 0.058.

For the "tools and skills" dimension, a weight of 0.108% was obtained. The final weight of the sub-indices for "use of new production machines and tools" is equal to 0.408, respectively, "proper organization and management in terms of technology" is equal to 0.269, and "examination of limitations in the use of technology" is equal to 0.162, "improvement of skills and experiences of human resources" equal to 0.091, "increase of information and technical knowledge" equal to 0.068.

Then "investment capability" gained a weight of 0.045 percent. The final weight of the sub-indices for "optimal allocation of capital" is equal to 0.429, "allocation of revenue share to research and development" equal to 0.334, respectively, "purchase of intangible technologies such as licenses and patents" equal to 0.143, "adequate purchase of tangible technology such as equipment and machinery "equal to 0.092.

Next, "process technology capability" gained a weight of 0.035 percent. The final weight of the sub-indices for "process efficiency by technology" is equal to 0.379, "compliance of production with engineering specifications" is equal to 0.281, "improvement of service delivery by technology" is equal to 0.175, and "reduction of process time," respectively. Equivalent to 0.096, the "reduction of operating costs" was equal to 0.067.

Finally, according to *Table 3*, the "capacity of main and support activities" gained a weight of 0.024 percent. The final weight of the sub-indices for "infrastructure development" is equal to 0.405, "upgrade of human resource management system" is equal to 0.253, "support for technology development" is equal to 0.178, "supply and supply of technology needs"are equal to 0.096, "financing for technology development" was equal to 0.067.

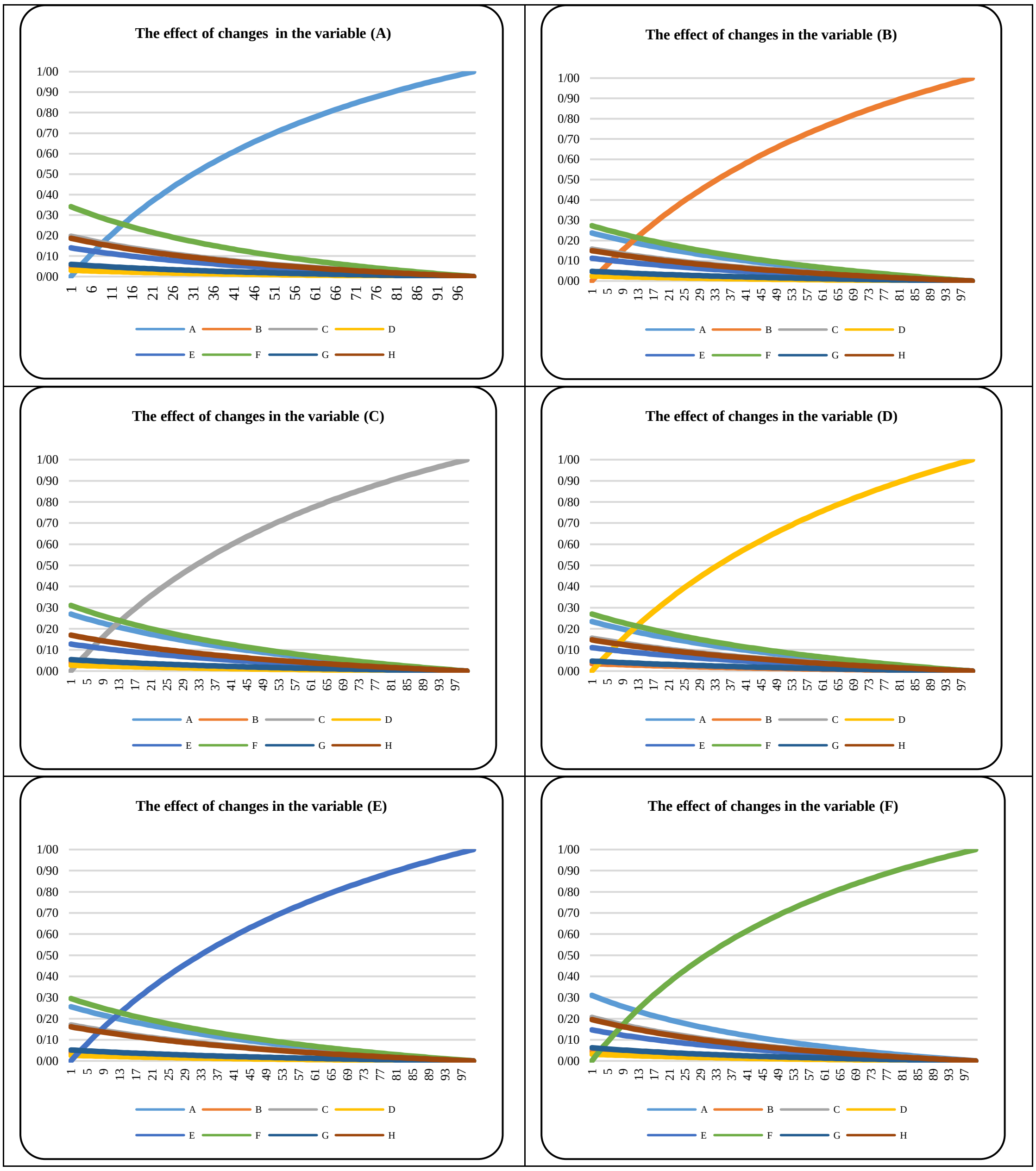
4.1 | Sensitivity Analysis

Sensitivity analysis approaches can be divided into two categories: deterministic and probabilistic, which are sometimes known as local and general approaches. The deterministic sensitivity analysis method is usually used if the model is very complex. In this case, the model with a small number of analyzes, with different combinations of parameters, one of which changes each time, and their effect on the outputs is

measured by initial analysis. Sensitivity analysis (parameter-induced) determines the crucial parameters of the model and their relative importance [17].

The terms uncertainty analysis and sensitivity analysis usually come together and are likely to overlap. The purpose of parameter sensitivity analysis is to determine the critical parameters of the model and their relative importance. For example, is parameter a more urgent than parameter B? Or what is their significance to C? In other words, can the parameters be ranked in order of importance? [24].

In the proposed sensitivity analysis, each variable starts to change from 0 to 100%, and the effect of these changes on other variables in the study is investigated. Due to the complexity of the relationship between the variables, there will always be a nonlinear relationship between the changes. Super decision software is used for analysis. It has been shown in all diagrams that the criteria with a higher weight will accept the highest slope of changes from the increasing trend of the growing variable, and the less critical variables will tend to zero with a lower slope.



Ehsani et al. | Int. J. Res. Ind. Eng. 12(1) (2023) 88-105

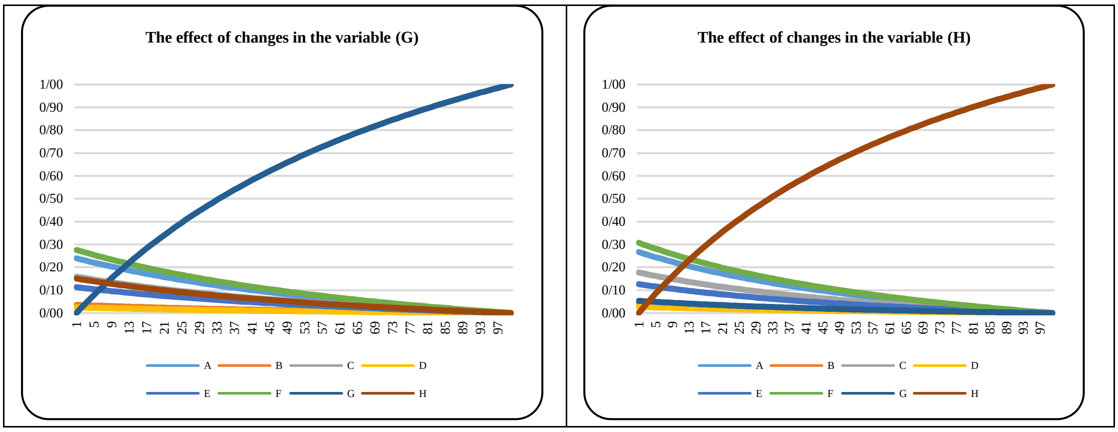


Fig. 1. Sensitivity analysis.

5 | Discussions and Conclusions

This study shows new drivers and relationships beyond existing literature. After analysis, we got some results different from the past. This study contributes to the literature in the following ways. The first is the definition and dimensions of technology capabilities. The second contribution is the empirical corroboration that technology capabilities are also relevant for the Iran industry.

The literature suggests that Western-generated theories may not fully apply to societies with vastly different socioeconomic conditions. Third, this study contributes to the debates on the value of technology capabilities.

The finding shows that technology capabilities enable firms to be sensitive to opportunities and threats, seize possible chances and implement the change necessary to enhance environmental adaptability and ultimately achieve competitive advantage.

The result of this study suggests a high priority for the identified drivers: "strategic technology capability" and "product technology capability" in the main criteria and "technology development" and "implementation and application of technology" in the sub-criteria.

Researchers in previous studies have proposed various drivers. For example, the driver of "flexible technology infrastructure" [21], "internal competence and competence or relative strength of the company to other companies" [34], the driver of "appropriate supply chain" [35], the driver "providing a comprehensive approach" [7], "technology model" [18], "operational agility and capital agility" driver [23], "dynamic capability" [12], also suggested "environmental innovation performance"driver by Wu et al. [37] and finally, "technology capability infrastructure capability" [29].

New drivers have been identified and prioritized in the study, which has not been mentioned in previous studies, and by considering the mentioned drivers, new results can be obtained.

The results of this study increase our awareness of the propulsion indicators of the supply chain technology capability model and highlight the importance of each of these indicators. Based on the results of the fuzzy hierarchical analysis method for the indicators of the supply chain technology capability model, the following items are presented:

Regarding key metrics, automakers in the supply chain need to pay more attention to the "strategic technology capability" issue. Based on the results, manufacturers should put the main criterion of "strategic technology capability" on the agenda and review it. The adoption of these strategies, along with other strategies and various policies in various industrial dimensions, has played a significant role in the relative

advancement of industries. Some of these strategies are reverse value chain strategy, reverse life cycle strategy, process expertise strategy, product technology pioneering strategy, and pioneering strategy in applying new technologies. Organizations need to improve "technology development leadership." There are two ways to design a successful model for technology development and commercialization. First, reviewing and analyzing the behavioral models and implementation of successful technologies developed and commercialized and modeling them, and second, recognizing the process of technology development and commercialization and systematically reviewing its literature to formulate the technology development process. "Developing a vision and strategy for technological innovation" is the next priority for improvement. For this purpose, the organization can formulate a vision and strategy in the areas of strategic innovation in the market, strategic innovation in the product, strategic innovation in organizational processes, strategic innovation in organizational structure, strategic innovation in human resource development, strategic innovation in customer relations and strategic creation of organizational plan and action. "Identifying internal strengths and weaknesses and external opportunities and threats of technology" is of secondary importance. In the next priority, special attention should be paid to the "performance-based technology support" index and creating well-codified monitoring programs.

The next priority is the "product technology capability" index. In this section, manufacturing companies are suggested to pay special attention to the "implementation and application of technology." For this purpose, six tools of patent analysis, portfolio management, roadmap development, S curve, port stage, and value analysis can be used to create, implement, and apply technology within the organization. In the "supplier technology and supply chain" field, there is a need to focus on the "technology transfer and development" sub-index. Technology transfer and development can be considered the process of using existing technologies to create innovations and new products. Transferring scientific and technical findings from one organization to another promotes the level of development and commercialization. Applying an organized and orderly procedure for technology transfer and development transforms this process from a rare and random event into a structured one. This can bring significant value to emerging industries, especially in critical technologies. To achieve this value, it is necessary to fully understand the technology transfer process and apply it properly in the organization. The "capabilities of the organization" criterion should develop specialized programs for "technology monitoring."

At the beginning of the research, after reviewing the literature and identifying technology capability indicators through content validity, the indicators extracted by selected experts in the automotive industry supply chain field were approved. Data analysis was performed using Excel software, and the priority of the main variables was determined as follows:

Similarly, the sub-indices related to the main variables were also prioritized in the following order:

- *Strategic technology capability: leading technology development; developing a vision and strategy for technology innovation; identifying internal strengths and weaknesses and external technological opportunities and threats; technology-based performance support.*
- *Product technology capability: implementation and application of technology; update and use of technology; save money; technology creation and transfer.*
- *Technology suppliers and supply chain: technology transfer and development; acceptance of new technologies; the extent of technology knowledge absorption; operational effectiveness; improving logistical efficiency.*
- *Tools and skills: using new production machines and tools; proper organization and management in the direction of technology; examining the limitations in using technology; improving human resource skills and experiences; increasing the amount of information and technical knowledge.*
- *Organizational capabilities: technology supervision; reproduction and expansion of technology; maintenance of existing technology; adaptation and improvement of technology; capability and technology updates.*
- *Investment capability: optimal capital allocation; allocate a share of revenue to research and development; purchase of intangible technology such as licenses and patents; adequate purchase of tangible technology such as equipment and machinery.*

Ehsani et al.| Int. J. Res. Ind. Eng. 12(1) (2023) 88-105

- *Process technology capability: process efficiency by technology; compliance of production with engineering specifications; improving service delivery by technology; reducing process time; reducing operating costs.*
- *The capability of core and support activities: infrastructure development; improving the human resource management system; supporting technology development; procurement and supply of technology needs; financing for technology development.*

During the research period, researchers encountered several limitations, including limitations related to the research design, such as the impossibility of identifying all the factors influencing the research design, and limitations and lack of similar research that directly addresses the research topic, as well as constraints related to the effectiveness of research due to conducting research in the automotive industry and its specific community, which can limit the generalizability of the findings. It also mentioned the limitations of statistical research methods, such as weaknesses in research tools (for example, the fuzzy hierarchical analysis method has limitations and disadvantages) and the lack of cooperation of some people to complete the questionnaire.

Conflict of Interest

All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission isoriginal work and is not under review at any other publication.

References

[1] Ajripour, I., Asadpour, M., & Tabatabaie, L. (2019). A model for organization performance management applying MCDM and BSC: a case study. *Journal of applied research on industrial engineering*, *6*(1), 52-70. http://www.journal-aprie.com/article_83034.html

[2] Akoğlu, N., Civelek, M. E., & Başaran, Y. (2022). The role of information technology in the effect of innovation capability on logistics service quality. *İşletme araştırmaları dergisi*, *14*(1), 249-265. https://www.ceeol.com/search/article-detail?id=1049764

[3] Aliakbari Nouri, F., Khalili Esbouei, S., & Antucheviciene, J. (2015). A hybrid MCDM approach based on fuzzy ANP and fuzzy TOPSIS for technology selection. *Informatica*, *26*(3), 369-388.

[4] Annarelli, A., Battistella, C., & Nonino, F. (2020). Competitive advantage implication of different product service system business models: consequences of 'not-replicable'capabilities. *Journal of cleaner production*, *247*, 119121. https://doi.org/10.1016/j.jclepro.2019.119121

[5] Azizi, E., Javanshir, H., Jafari, F., & Ebrahimnejad, S. (2021). Designing a sustainable agile retail supply chain using multi-objective optimization methods (case study: SAIPA company). *Scientia Iranica*, *28*(5), 2933-2947. DOI: 10.24200/sci.2019.53311.3179

[6] Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European journal of operational research*, *95*(3), 649-655.

[7] CORDIS (2015). *Integrated health technology assessment for evaluating complex technologies* (ID: 306141). https://cordis.europa.eu/project/id/306141

[8] De Guimaraes, J. C. F., Severo, E. A., & de Vasconcelos, C. R. M. (2018). The influence of entrepreneurial, market, knowledge management orientations on cleaner production and the sustainable competitive advantage. *Journal of cleaner production*, *174*, 1653-1663.

[9] De Mori, C., Batalha, M. O., & Alfranca, O. (2016). A model for measuring technology capability in the agrifood industry companies. *British food journal*. *188*(6), 1422-1461. DOI:10.1108/BFJ-10-2015-0386

[10] Deepu, T. S., & Ravi, V. (2021). Supply chain digitalization: an integrated MCDM approach for inter-organizational information systems selection in an electronic supply chain. *International journal of information management data insights*, *1*(2), 100038. https://doi.org/10.1016/j.jjimei.2021.100038

[11] Deng, H. (1999). Multicriteria analysis with fuzzy pairwise comparison. *International journal of approximate reasoning*, *21*(3), 215-231. https://doi: 10.1109/Fuzzy.1999.793038

[12] Ferreira, J., Coelho, A., & Moutinho, L. (2020). Dynamic capabilities, creativity and innovation capability and their impact on competitive advantage and firm performance: the moderating role of entrepreneurial orientation. *Technovation*, *92*, 102061. https://doi.org/10.1016/j.technovation.2018.11.004

[13] Genus, A., & Iskandarova, M. (2020). Transforming the energy system? Technology and organisational legitimacy and the institutionalisation of community renewable energy. *Renewable and sustainable energy reviews*, *125*, 109795. https://doi.org/10.1016/j.rser.2020.109795

[14] Halder, P. K., Karmarker, C. L., Kundu, B., & Daniel, T. (2018). Evaluation of factors affecting the productivity of RMG in Bangladesh: a fuzzy AHP approach. *International journal of research in industrial engineering*, *7*(1), 51-60. DOI: 10.22105/riej.2017.94987.1011

[15] Hernández, C. C. P., Gómez, G. L., & Hernández, D. G. (2017). Evolution of state clusters related with technological capability in Mexico: application of a multivariate statistical analysis of cluster. *Contaduría y administración*, *62*(2), 528-555. https://doi.org/10.1016/j.cya.2017.02.003

[16] Huang, C. C., & Huang, S. M. (2020). External and internal capabilities and organizational performance: does intellectual capital matter?. *Asia pacific management review*, *25*(2), 111-120. https://doi.org/10.1016/j.apmrv.2019.12.001

[17] Iooss, B., & Lemaître, P. (2015). A review on global sensitivity analysis methods. *Uncertainty management in simulation-optimization of complex systems: algorithms and applications*, 101-122. https://doi.org/10.1007/978-1-4899-7547-8_5

[18] Jajja, M. S. S., Asif, M., Montabon, F., & Chatha, K. A. (2020). The indirect effect of social responsibility standards on organizational performance in apparel supply chains: a developing country perspective. *Transportation research part E: logistics and transportation review*, *139*, 101968. https://doi.org/10.1016/j.tre.2020.101968

[19] Kavilal, E. G., Venkatesan, S. P., & Kumar, K. H. (2017). An integrated fuzzy approach for prioritizing supply chain complexity drivers of an Indian mining equipment manufacturer. *Resources policy*, *51*, 204-218. https://doi.org/10.1016/j.resourpol.2016.12.008

[20] Kuan, M., & Chen, Y. (2014). A hybrid MCDM framework combined with DEMATEL-based ANP to evaluate enterprise technological innovation capabilities assessment. *Decision science letters*, *3*(4), 491-502.

[21] Lim, S., & Trimi, S. (2014). Impact of information technology infrastructure flexibility on the competitive advantage of small and medium sized-enterprises. *Journal of business & management*, *3*(1), 1-12.

[22] Liu, G., Fan, S., Tu, Y., & Wang, G. (2021). Innovative supplier selection from collaboration perspective with a hybrid mcdm model: a case study based on nevs manufacturer. *Symmetry*, *13*(1), 143.

[23] Mikalef, P., & Pateli, A. (2017). Information technology-enabled dynamic capabilities and their indirect effect on competitive performance: findings from PLS-SEM and fsQCA. *Journal of business research*, *70*, 1-16. https://doi.org/10.1016/j.jbusres.2016.09.004

[24] Motaghed, S., Yazdani, A., Nicknam, A., & Khanzadi, M. (2018). Sobol sensitivity generalization for engineering and science applications. *Journal of modeling in engineering*, *16*(54), 217-226. (**In Persian**). DOI: 10.22075/jme.2017.12259.1221

[25] Najafi, S. E., Amiri, M., & Abdolah Zadeh, V. (2015). Ranking practicable technologies within the science and technology corridor of Isfahan, using MCDM techniques. *Journal of applied research on industrial engineering*, *2*(3), 139-153. http://www.journal-aprie.com/article_42518.html

[26] Zhang, Y., Sun, J., Yang, Z., & Wang, Y. (2020). Critical success factors of green innovation: technology, organization and environment readiness. *Journal of cleaner production*, *264*, 121701. https://doi.org/10.1016/j.jclepro.2020.121701

[27] Oghojafor, B. E. A.26, Kuye, O. L., Ogunkoya, O. A., & Shobayo, P. B. (2014). Competitive strategies, technological capabilities and organizational performance: evidence from Nigerian manufacturing industry. *Arabian journal of business and management review (Nigerian chapter)*, *2*(1), 11-22.

[28] Pantha, R. P., Islam, M., Akter, N., & Islam, E. (2020). Sustainable supplier selection using integrated data envelopment analysis and differential evolution model. *Journal of applied research on industrial engineering*, *7*(1), 25-35.

[29] Qin, J., van der Rhee, B., Venkataraman, V., & Ahmadi, T. (2021). The impact of IT infrastructure capability on NPD performance: the roles of market knowledge and innovation process formality. *Journal of business research*, *133*, 252-264. https://doi.org/10.1016/j.jbusres.2021.04.072

[30] Radfar, R., & Khamseh, A. (2016). *Technilogy management (a comprehensive approach to technology, innovation and commercialization*. Scientific and Cultural Publications Company. (**In Persian**). https://www.gisoom.com

Ehsani et al.| Int. J. Res. Ind. Eng. 12(1) (2023) 88-105

[31] Saeedi Mehrabad, M., Aazami, A., & Goli, A. (2017). A location-allocation model in the multi-level supply chain with multi-objective evolutionary approach. *Journal of industrial and systems engineering*, *10*(3), 140-160.

[32] Sarmad, Z., Bazargan, A., & Hejazi, A. (2022). *Research methods in behavioral sciences*. Agah Publishing. (**In Persian**). https://www.adinehbook.com/gp/product/9643290514

[33] Shahzad, F., Du, J., Khan, I., Shahbaz, M., Murad, M., & Khan, M. A. S. (2020). Untangling the influence of organizational compatibility on green supply chain management efforts to boost organizational performance through information technology capabilities. *Journal of cleaner production*, *266*, 122029. https://doi.org/10.1016/j.jclepro.2020.122029

[34] Srivastava, M. K., Gnyawali, D. R., & Hatfield, D. E. (2015). Behavioral implications of absorptive capacity: the role of technological effort and technological capability in leveraging alliance network technological resources. *Technological forecasting and social change*, *92*, 346-358. https://doi.org/10.1016/j.techfore.2015.01.010

[35] Tripathy, S., Aich, S., Chakraborty, A., & Lee, G. M. (2016). Information technology is an enabling factor affecting supply chain performance in Indian SMEs: a structural equation modelling approach. *Journal of modelling in management*, *11*(1), 269-287.

[36] Tseng, S. T., & Levy, P. E. (2019). A multilevel leadership process framework of performance management. *Human resource management review*, *29*(4), 100668. https://doi.org/10.1016/j.hrmr.2018.10.001

[37] Wu, Y., Gu, F., Ji, Y., Guo, J., & Fan, Y. (2020). Technological capability, eco-innovation performance, and cooperative R&D strategy in new energy vehicle industry: evidence from listed companies in China. *Journal of cleaner production*, *261*, 121157. https://doi.org/10.1016/j.jclepro.2020.121157